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MORPHOLOGY OF THE ANTENNA OF *CAENOCHOLAX FENYESI* PIERCE (STREPSIPTERA: MYRMECOLACIDAE) BASED ON SCANNING ELECTRON MICROSCOPY

Dawn P. Derr and Jerry L. Cook

Department of Biological Sciences, Sam Houston State University, Huntsville, TX, 77341-2116, U.S.A. (e-mail: bio_jlc@shsu.edu)

Abstract.—The antenna of *Caenocholax fenyesi* Pierce includes two types of sensilla. Sensilla chaetica are located at the distal ends of segments three and four. These sparsely abundant sensilla are thought to be tactile sensory structures. Sensilla coeloconica are found abundantly on segments three through seven, including the flabellum of segment three. These sensilla coeloconica are chemoreceptors that are presumably used as pheromone receptors used in location of the female, which remains an endoparasite. The morphology of the antenna of *C. fenyesi* is shown using scanning electron microscopy.

Key Words: sensilla, antenna, morphology, *Caenocholax fenyesi*

Caenochoax fenyesi, a member of the strepsipteran family Myrmecolacidae, was first described by Pierce (1909). The description was based on four males collected in Cordoba, Veracruz, Mexico by Dr. A. Fenyes. No females were collected, and the host species was not identified. Subsequently, both sexes have been collected (Kathirithamby and Johnston 2003). Adult male *C. fenyesi* are free-living, while adult females are permanent endoparasites. Although most Strepsiptera are host specific, *C. fenyesi,* as well as other myrmecolacids, are distinctive in that females parasitize members of Orthopteroidea whereas males parasitize members of the family Formicidae (Hymenoptera) (Kathirithamby 1989). *Caenocholax fenyesi* appears to be either an atypical generalist among the Strepsiptera or a species complex, with males known to parasitize a variety of ant species (Cook et al. 2004). The adult male *C. fenyesi* lifespan is limited to a few hours (Cook 1996) and in this time it must locate the endoparasitic female to successfully mate. *Caenochoax fenyesi* has a widespread distribution ranging from Argentina to the southern United States (Cook et al 1997, Kathirithamby and Hughs 2002).

Pierce (1909), in his original description, and Bohart (1941), in a review of the order, described the adult male *Caenochoax fenyesi* antennae as being seven-jointed or segmented. Given that scanning electron microscopy (SEM) was not available, the descriptions are general and do not give any detail of cuticular sensilla of the antennae. In fact, little has been reported concerning the strepsipteran antennae, except for the morphological study by Kinzelbach (1971). Kinzelbach reported that strepsipterans have two types of antennal sensilla, sensilla trichodea and sensilla basiconica. Additionally, Strepsiptera have a sensory depression, named Hofeneder's organ, on the fourth antennal segment, except in the families Elenchidae and Bohartilidae where it is on the third segment (Hofeneder 1910, Kinzelbach 1971, Kathirithamby 1989).

Based on the work of Snodgrass (1935)

and Schneider (1964), Zachurak (1985) compiled a listing of ten categories or types of insect sensilla. By definition sensilla are organs that possess "structural and functional mechanisms needed for accepting stimuli, generating a nerve impulse message and conducting this message to an appropriate receiving cell" (Zachurak 1985). Sensilla are found on several areas of the body, namely antennae, mouthparts, legs and wings, genitalia and anal cerci, as well as others; and come in many forms, to include hairs, bristles, spines, pegs, cones, plates and scales. In investigating sensilla, researchers often attempt to attribute some function to a given structure—chemoreceptor, thermoreceptor, and hygroreceptors—just to list a few. To understand both the morphology and function of sensilla, it is important to have an understanding of the life history of the organism.

Early studies of antennal sensilla yielded information on the number of types of sensilla on the flagella of numerous insects at both the adult (male and female) and some instar stages. For example, adult *Heliothis zea* (Lepidoptera) and *Stomoxys calcitrans* (Diptera) have four distinct types while *Apis mellifera* (Hymenoptera) have ten sensilla types (Zachurak 1985). Recent work using the scanning electron microscope has allowed for detailed study of the cuticular sensilla of Diptera (De Freitas Fernandes et. al. 2002), Hemiptera (Liang 2001) and Coleoptera (Merivee et. al. 2000, 2002) that includes not only typology but also size, number and distribution patterns.

Gross morphology of the antennae of *C. fenyesi* is described by Pierce (1909) as "seven jointed; the first two joints transverse, cylindrical, cupped; third joint transverse, cupped, but produced outwardly beneath in a long flabellum, which is almost as long as the metathorax; fourth joint transverse, cylindrical; fifth elongate five sixth as long as the width of the head; sixth seven-tenths as long as the fifth and slightly surpassed by the flabellum of the third; seventh four-fifth as long as the fifth." This description was accompanied by a figure, which we reproduce below to compare with the antennae of our study. Kathirithamby and Johnston (1992) provided a SEM of the head that included a portion of the antennae, but provided no antennal description. The objective of this study was to identify the different morphological types and location of cuticular sensilla on the antennae of adult male *Caenochoax fenyesi.*

Materials and Methods

Preserved specimens of adult male *Caenocholax fenyesi* from the collection at Sam Houston State University were studied using a scanning electron microscope. Male Strepsipteran specimens were obtained from parasitized individuals in colonies of *Solenopsis invicta* Buren collected from Brazos County, Texas.

Specimens preserved in 100% ethanol were air dried for 15 to 30 seconds on filter paper, mounted on aluminum SEM stubs, and coated with gold using a Cressington 108 sputter coater. Micrographs were taken using a VEGA TS 5130SB scanning electron microscope (Sam Houston State University, Huntsville, Texas) at 15 kV.

Morphological terminology used for classification is based on Schneider (1964) and Zacharuk (1985).

Results and Discussion

The antenna drawn by Pierce (1909) illustrated specimens from the type locality in Cordoba, Mexico. Pierce drew an antenna similar in form to the antennae of our study, but lacking any detail of the sensory structures. Figure 1 shows a comparison of Pierce's antenna with an antenna from the Texas specimens used for our study. The dimensions and shape of antennae were consistent to Fig. 1B in all specimens we viewed.

Non-sensory, multi-cellular processes of the antennal cuticle are found on the surface of all segments of the antennae, but are excluded from the areas where sensilla are located. These are platelike extensions ar-

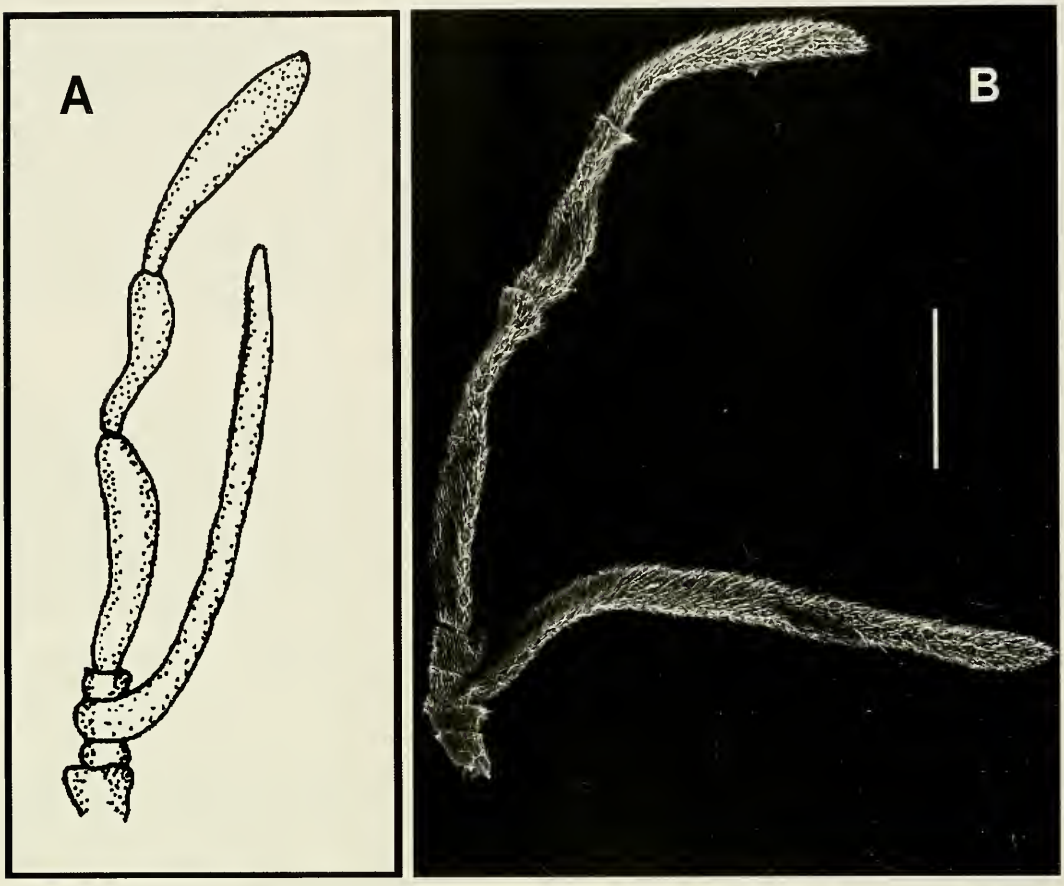
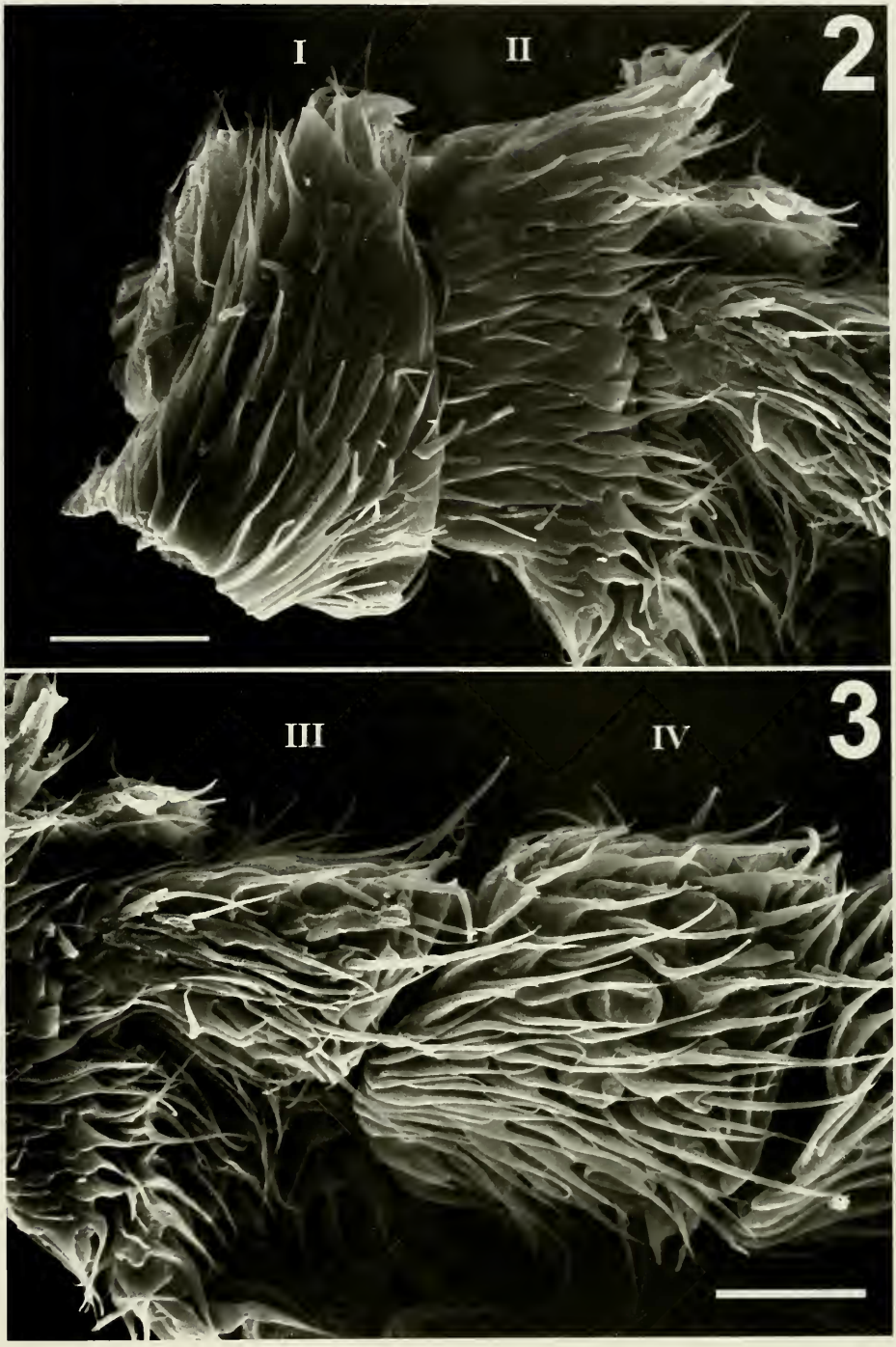


Fig. 1. Antenna of *Caenocholax fenyesi.* 1A, Antenna redrawn after Pierce 1909. 1B, Antenna SEM taken at 453×; scale bar = 100 μm.

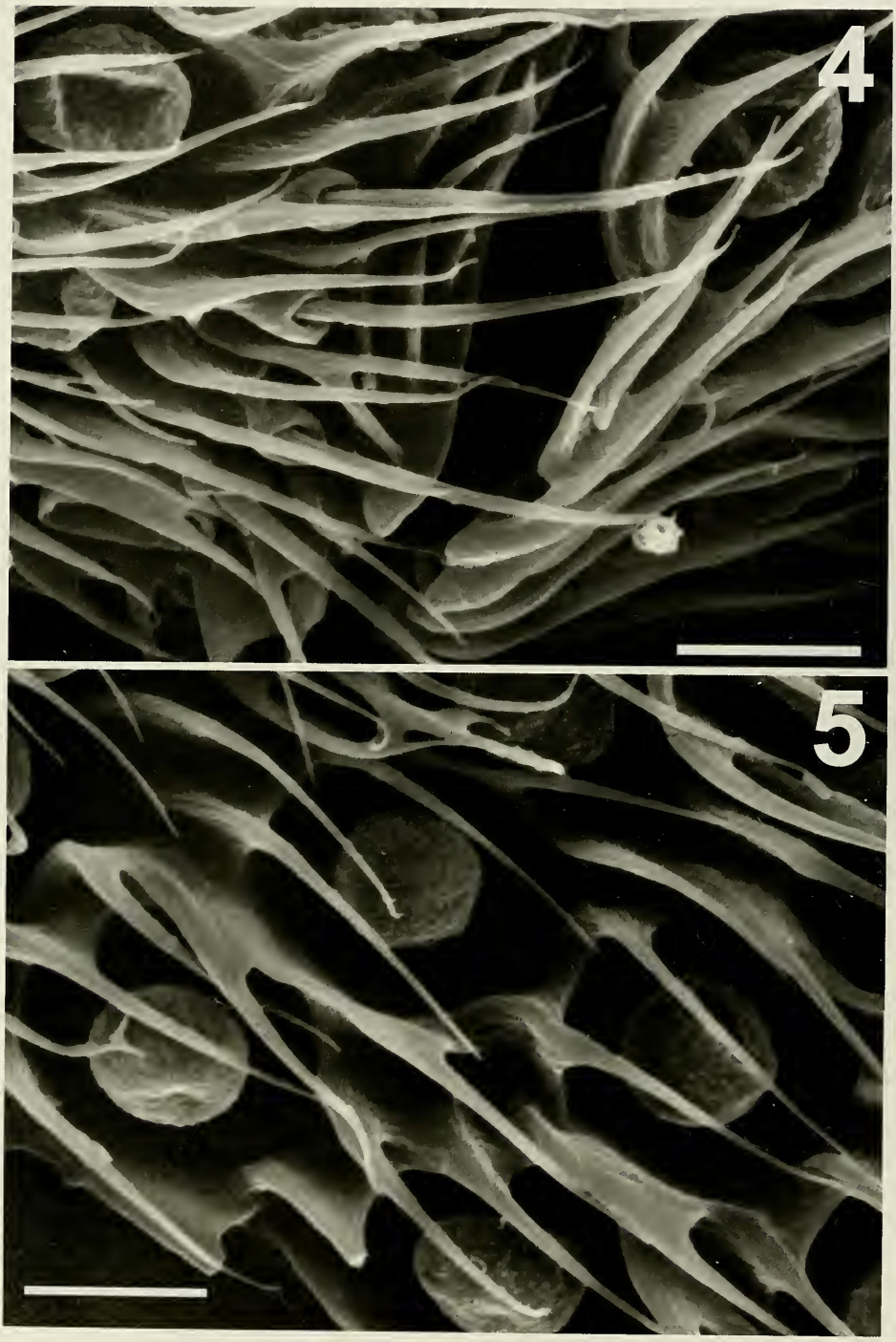
ranged in alternating rows and terminating with a slender spine or hairlike structure. We also found these extensions in conjunction with sensory structures, the cuticle surrounds the sensilla and may provide protection. These are the only processes found on the first and second basal segments of the antenna (Fig. 2).

Two types of sense organs were identified—sensilla chaetica (ch) and sensilla coeloconica (co). Sensilla chaetica were found on segments three and four, while sensilla coeloconica were located on segments three through seven.

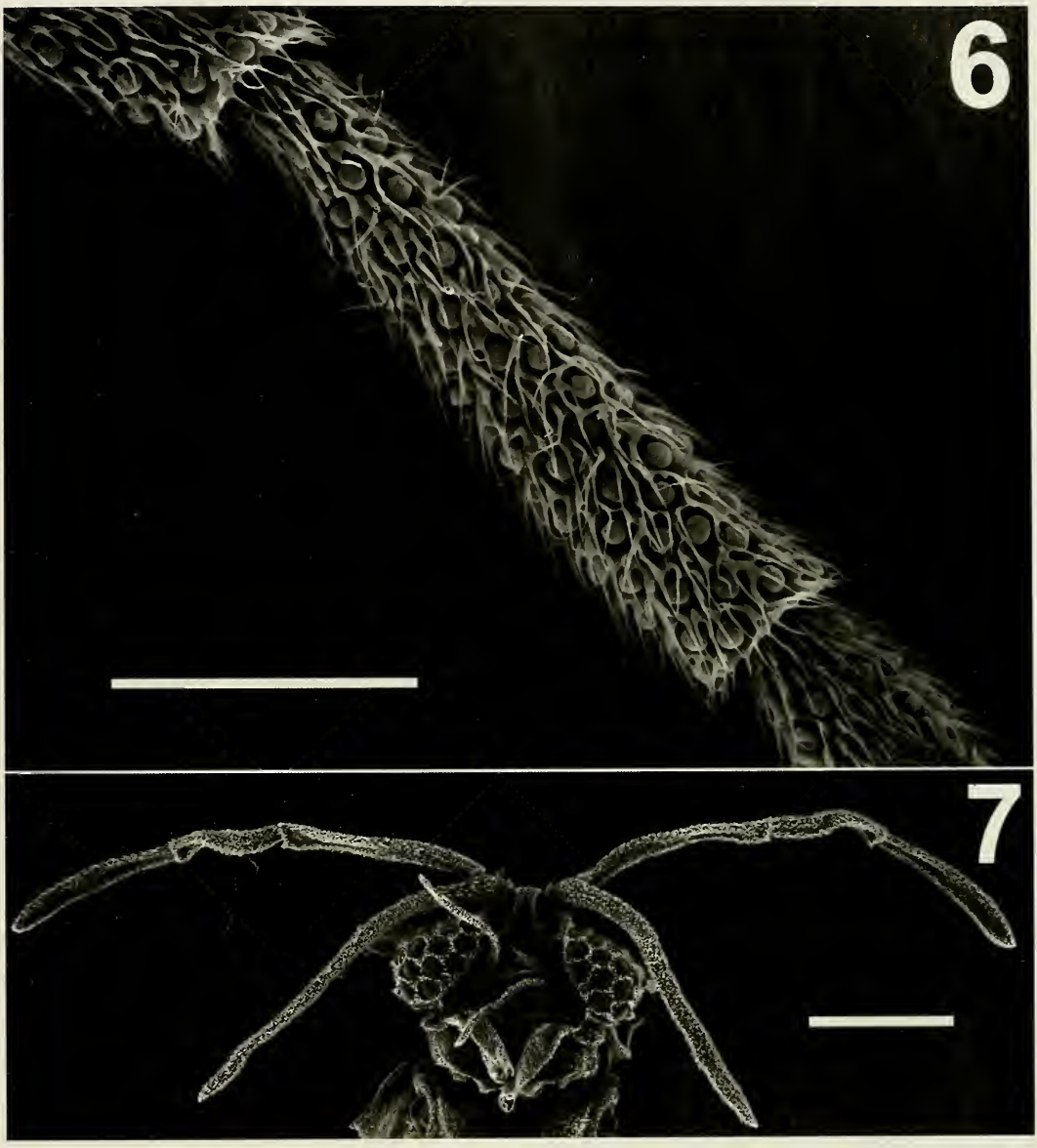
Sensilla chaetica are sensory bristles or spines usually set into a socket. They are generally thought to be tactile, but some have been identified as chemoreceptors. Innervation is by one or more neurons (Zacharuk 1985). In *Caenochoax fenyesi* these sensilla are sparsely located along the distal third of segment three (on the margin near the attachment to segment four) and in a similar location on segment four (Fig. 3). The extended portion, the flabellum, of segment three does not contain any chaetica sensilla. The bristles range from 7.3 to 11.5 μm from the socket insertion and taper slightly from base to distal end (Fig. 4). As these sensilla are usually considered tactile, the location may suggest that they are used in confirming the positioning of the long flagellar segment. Chaetica sensors have been identified on the flagella of Lepidoptera, Orthoptera, Blattaria, Hemiptera, Coleoptera, Siphonaptera, and Diptera



Figs 2–3. Antennal segments of *Caenocholax fenyesi*. 2, Basal antennal segments (segments I & II). 3, Segments III & IV. Scale bar = 10 μm.



Figs. 4–5. Sensilla of *Caenocholax fenyesi* antennal segments. 4, Sensilla chaetica on antennal segment III. 5, Sensilla coeloconica surrounded by non-sensory structures. Scale bar = 5 μm.



Figs. 6–7. Male *Caenocholax fenyesi*. 6, Sensilla coeloconica on the three terminal antennal segments. Segment VII is at the bottom right; Scale bar = 50 μm. 7, Ventral view of the head of *Caenocholax fenyesi*. Scale bar = 200 μm.

(Schneider, 1964). These structures are presumably the same as those identified in other Strepsiptera by Kinzelbach (1971) but labeled as sensilla trichodea. The difference between these two sensilla is that sensilla chaetica are set in a socket while sensilla trichodea are freely moveable on a basal membrane with variable basal insertion on the cuticle (Zacharuk 1985). The sensilla on the antenna of *C. fenyesi* are clearly emerging from sockets and bristlelike; and are therefore sensilla chaetica. Our study had the luxury of seeing these structures with the electron microscope, making it easier to distinguish between sensilla chaetica and sensilla trichodea. However, some strepsip-

terans may indeed have sensilla trichodea, or a combination of both of these sensilla. More studies using an electron microscope to examine other strepsipteran species is needed to elucidate which of these structures are present on strepsipteran antennae.

Sensilla coeloconica are thin-walled sensory cones on the floor of depressions or pits in the cuticle. The pegs are innervated by four or five neurons forming a bundle that terminates at the tip of the peg. Coeloconic organs are most often reported to be thermo-, chemo-, or hygroreceptors (Zacharuk 1985). In *Caenochoax fenyesi* the pegs appear to be smooth, ball-like structures nestled in deep depressions that are surrounded by numerous non-sensory, multi-cellular processes (Fig. 5). The pegs range from 2.5 to 6.5 μm. Smaller pegs 2.5 to 4.2 μm are located on segment four, while pegs from 4.5 to 6.5 μm can be found on the elongated portion of segment three as well as segments five, six and seven (Fig. 6). Where coeloconica pegs are found, they are evenly distributed. Sensilla coeloconica have been described on antennae of Hemiptera (Liang 2001), Diptera (De Freitas Fernandes et. al. 2002), Coleoptera (Merivee et. al. 2000, 2002), and Orthoptera (Schneider 1964). The life history of the adult male *Caenochoax fenyesi* suggests that chemoreceptivity plays an important role in locating a female with which to mate. *Caenocholax fenyesi* males only live a few hours, in which time they must locate an endoparasitic adult female, if they are going to successfully mate (Cook 1996). The large number of coeloconica sensilla on the antennae and their natural history may reinforce the proposition that these sense organs are chemoreceptors. The distribution of the coeloconica sensilla on the head of the male *C. fenyesi* could facilitate detection and location of pheromones given off by the female (Fig. 7).

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